Total $V = 0.0220 + 0.0375 = 0.0595$ L

$M_{NH_3} = 0$; $M_{NH_4^+} = \dfrac{0.0126 \text{ mol}}{0.0595 \text{ L}} = 0.212$; $M_{Cl^-} = \dfrac{0.0165 \text{ mol}}{0.0595 \text{ L}} = 0.277$;

$M_{H^+} = \dfrac{0.0039 \text{ mol}}{0.0595 \text{ L}} = 0.0655$

(f) $6H^+(aq) + 2Al(s) \rightarrow 3H_2(g) + 2Al^{3+}(aq)$; $0.212 \text{ L} \times \dfrac{0.493 \text{ mol } H^+}{1 \text{ L}} \times \dfrac{2(26.98) \text{ g Al}}{6 \text{ mol } H^+} = 0.940 \text{ g Al}$

$\% \text{ Al} = \dfrac{0.940}{2.500} \times 100 = 37.6\%$

PROBLEMS

1. $\dfrac{10 \text{ g}}{0.10 \text{ L}} \times \dfrac{1 \text{ mol}}{17 \text{ g}} = 5.9 \, M$

3. (a) $\dfrac{20.0 \text{ g } CoCl_3}{4.50 \text{ L}} \times \dfrac{1 \text{ mol}}{165.28 \text{ g}} = 0.0269 \, M \, CoCl_3$; $M_{Co^{3+}} = 0.0269$; $M_{Cl^-} = 3(0.0269) = 0.0807$

(b) $\dfrac{20.0 \text{ g } Ni_2(SO_4)_3}{4.50 \text{ L}} \times \dfrac{1 \text{ mol}}{405.9 \text{ g}} = 0.0109 \, M \, Ni_2(SO_4)_3$;

$M_{Ni^{2+}} = 2(0.0109) = 0.0218$; $M_{SO_4^{2-}} = 3(0.0109) = 0.0327$

(c) $\dfrac{20.0 \text{ g } NaMnO_4}{4.50 \text{ L}} \times \dfrac{1 \text{ mol}}{141.93 \text{ g}} = 0.0313 \, M \, KMnO_4$; $M_{K^+} = M_{MnO_4^-} = 0.0313$

(d) $\dfrac{20.0 \text{ g } FeBr_2}{4.50 \text{ L}} \times \dfrac{1 \text{ mol}}{215.65 \text{ g}} = 0.0206 \, M \, FeBr_2$; $M_{Fe^{2+}} = 0.0206$; $M_{Br^-} = 2(0.0206) = 0.0412$

5. (a) $\dfrac{0.155 \text{ mol}}{1 \text{ L}} \times 0.400 \text{ L} \times \dfrac{121.6 \text{ g}}{1 \text{ mol}} = 7.54 \text{ g } Sr(OH)_2$ in water to form 0.400 L of solution.

(b) $\dfrac{0.333 \text{ mol}}{1 \text{ L}} \times 1.75 \text{ L} \times \dfrac{96.09 \text{ g}}{1 \text{ mol}} = 56.0 \text{ g } (NH_4)_2CO_3$ in water to form 1.75 L of solution.

7. (a) mol $Al(NO_3)_3 = \dfrac{50.00 \text{ g}}{213.0 \text{ g/mol}} = 0.2347$; $V = \dfrac{0.2347 \text{ mol}}{0.8500 \text{ mol/L}} = 0.2761$ L

(b) $V = \dfrac{0.5000 \text{ mol}}{0.8500 \text{ mol/L}} \times \dfrac{10^3 \text{ mL}}{1 \text{ L}} = 588.2$ mL

(c) required: $2.500 \text{ L} \times 0.8500 \text{ mol/L} = 2.125 \text{ mol} = 452.6 \text{ g } Al(NO_3)_3$; need: (452.6 - 50.00)g = 402.6 g

(d) $(0.0500 \text{ L})(0.450 \text{ mol/L}) = V_c(0.8500 \text{ mol/L})$; $V_c = 26.5$ mL; dilute to 50.0 mL

9. mol KOH in I and II = 0.07000 L $\times$ 0.203 mol/L = 0.0142
   mol KOH in I = 0.03000 L $\times$ 0.125 mol/L = 0.00375
   mol KOH in II = (0.0142 – 0.00375) mol = 0.01045
   M_{KOH} in II = 0.01045 mol/0.04000 L = 0.261M

11. (a) Na_2SO_4 (soluble) (b) $Fe(NO_3)_3$ (soluble) (c) AgCl (d) $Cr(OH)_3$

13. (a) Add a solution of Na_2CO_3, filter.
    (b) Add a solution of $CuSO_4$, filter.
    (c) Add a solution of Na_2CO_3, filter.

15. (a) $Mg^{2+}(aq) + 2\ OH^-(aq) \rightarrow Mg(OH)_2(s)$
    (b) $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
    $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

17. (a) no reaction
    (b) $2\,Ag^+(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s)$
    (c) $2\,Co^{3+}(aq) + 3\ CO_3^{2-}(aq) \rightarrow Co_2(CO_3)_3(s)$
    (d) $3\ Ba^{2+}(aq) + 2\ PO_4^{3-}(aq) \rightarrow Ba_3(PO_4)_2(s)$

19. (a) no reaction
    (b) $3\ Ca^{2+}(aq) + 2\ PO_4^{3-}(aq) \rightarrow Ca_3(PO_4)_2(s)$
    (c) $Zn^{2+}(aq) + 2\ OH^-(aq) \rightarrow Zn(OH)_2(s)$
    (d) $Fe^{3+}(aq) + 3\ OH^-(aq) \rightarrow Fe(OH)_3(s)$

21. (a) $Co^{3+}(aq) + 3\ OH^-(aq) \rightarrow Co(OH)_3(s)$
    mol OH^- = (0.02500 L)(0.0630 mol/L) = 0.001575 ; mol Co^{3+} = 0.001575 mol/3 = 0.000525
    $V = \dfrac{0.000525\text{ mol}}{0.5000\text{mol/L}}$ = 0.00105 L = 1.05 mL

    (b) $2\ Co^{3+}(aq) + 3\ CO_3^{2-}(aq) \rightarrow Co_2(CO_3)_3(s)$
    mol $CO_3^{2-} = \dfrac{5.00\text{ g}}{106.0\text{ g/mol}}$ = 0.0472
    mol Co^{3+} = (0.0472 mol) $\times$ 2/3 = 0.0314 ; $V = \dfrac{0.0314\text{ mol}}{0.5000\text{ mol/L}}$ = 0.0628 L = 62.8 mL

(c) $Co^{3+}(aq) + PO_4^{3-}(aq) \rightarrow CoPO_4(s)$

mol PO_4^{3-} = (0.01250 L)(0.1249 mol/L) = 0.001561 mol = mol Co^{3+}

$V = \dfrac{0.001561 \text{ mol}}{0.5000 \text{ mol/L}} = 0.003122 \text{ L} = 3.122 \text{ mL}$

23. (a) $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

mol Ag^+ = (0.05000 L)(0.0250 mol/L) = 0.00125 = mol Cl^-

$V = \dfrac{0.00125 \text{ mol}}{0.120 \text{ mol/L}} = 0.0104 \text{ L} = 10.4 \text{ mL}$

(b) 0.00125 mol $\times$ 143.4 g/mol = 0.179 g AgCl

25. mol PO_4^{3-} = mol Na_3PO_4 = (0.01500 L)(0.1386 mol/L) = 0.002079

mol Ca^{2+} = mol $Ca(NO_3)_2$ = (0.02000 L)(0.2118 mol/L) = 0.004236

If PO_4^{3-} is limiting: $0.002079 \text{ mol} \times \dfrac{310.18 \text{ g } Ca_3(PO_4)_2}{2 \text{ mol } PO_4^{3-}} = 0.3224 \text{ g}$

If Ca^{2+} is limiting: $0.004236 \text{ mol} \times \dfrac{310.18 \text{ g } Ca_3(PO_4)_2}{3 \text{ mol } Ca^{2+}} = 0.4380 \text{ g}$

0.3224 g of $Ca_3(PO_4)_2$ are obtained

27. (a) strong acid (b) strong base (c) weak acid (d) weak base

29. (a) H^+ (b) H^+ (c) HNO_2 (d) H^+ (e) $HC_3H_5O_3$

31. (a) OH^- (b) $(CH_3)_3N$ (c) $C_6H_5NH_2$ (d) OH^-

33. (a) $HNO_2(aq) + OH^-(aq) \rightarrow NO_2^-(aq) + H_2O$

(b) $HF(aq) + OH^-(aq) \rightarrow F^-(aq) + H_2O$

(c) $H^+(aq) + C_6H_5NH_2(aq) \rightarrow C_6H_5NH_3^+(aq)$

35. (a) $H^+(aq) + OH^-(aq) \rightarrow H_2O$ (b) OK ($B^- = CH_3NH_2$)

(c) OK ($B^- = NH_3$) (d) $H^+(aq) + OH^-(aq) \rightarrow H_2O$

(e) $HNO_2(aq) + OH^-(aq) \rightarrow H_2O + NO_2^-(aq)$

37. $H^+(aq) + OH^-(aq) \rightarrow H_2O$

mol $OH^- = 2(\text{mol } Ba(OH)_2) = 2 \times \dfrac{0.216 \text{ g}}{171.3 \text{ g/mol}} = 0.00252 = \text{mol } H^+$

M_{HNO_3} = 0.00252 mol/0.0200 L = 0.126

39. (a) $H_2SO_3(aq) + 2\ OH^-(aq) \rightarrow 2\ H_2O + SO_3^{2-}(aq)$

mol H_2SO_3 = 0.0325 L × 0.569 mol/L = 0.0185 ; mol OH^- = 2 × 0.0185 = 0.0370

$V = \dfrac{0.0370 \text{ mol}}{1.222 \text{ mol/L}}$ = 0.0303 L = 30.3 mL

(b) $H_2C_2O_4(aq) + 2\ OH^-(aq) \rightarrow 2\ H_2O + C_2O_4^{2-}(aq)$

mol $H_2C_2O_4 = \dfrac{5.00 \text{ g}}{90.04 \text{ g/mol}}$ = 0.0555 ; mol OH^- = 2 × 0.0555 = 0.111

$V = \dfrac{0.111 \text{ mol}}{1.222 \text{ mol/L}}$ = 0.0909 L = 90.9 mL

(c) $HC_2H_3O_2(aq) + OH^-(aq) \rightarrow H_2O + C_2H_3O_2^-(aq)$

mol $HC_2H_3O_2 = \dfrac{15.0 \text{ g} \times 0.88}{60.05 \text{ g/mol}}$ = 0.22 = mol OH^-

$V = \dfrac{0.22 \text{ mol}}{1.222 \text{ mol/L}}$ = 0.18 L = 1.8 $\times 10^2$ mL

41. mol OH^- = mol KOH = 0.3300 L × 0.2000 mol/L = 0.0660

0.06600 mol OH^- × 1 mol HX/2 mol OH^- × 100.0 g HX/mol = 3.3000 g HX

$V_{HX} = \dfrac{3.300 \text{ g}}{1.200 \text{g/mL}}$ = 2.750 mL

43. mol OH^- = (1.325 mol/L)(0.06652 L) = 0.08814 = mol H^+

0.08814 mol H^+ × 1 mol H_2SO_4/2 mol H^+ = 0.004407 mol/0.0100 L = 4.407 M

It does not.

45. mol H^+ = (0.275 mol/L)(0.0155 L) = 0.00426 = mol $NaHCO_3$

mass $NaHCO_3$ = (0.00426 mol)(84.01 g/mol) = 0.358 g

% $NaHCO_3 = \dfrac{0.358}{0.500} \times 100\%$ = 71.6 %

47. mol $H_2C_4H_4O_6 = \dfrac{12.0 \text{ g}}{150.09 \text{ g/mol}}$ = 0.0800 ; mol KOH = 2 × 0.0800 mol = 0.160

mass KOH = 0.160 mol × 56.11 g/mol = 8.98 g; mass solution = $8.98 \text{ g} \times \dfrac{100.0}{5.00} = 1.80 \times 10^2$ g

$V = \dfrac{1.80 \times 10^2 \text{ g}}{1.045 \text{ g/cm}^3}$ = 172 cm^3

49. (a) NO: N = +2, O = -2 (b) NH_3: N = -3, H = +1

(b) K_2O_2: K = +1, O = -1 (d) ClO_3^-: Cl = +5, O = -2

51. (a) P = +5, O = -2 (b) N = -3, H = +1 (c) C = +4, O = -2

(d) S = +2, O = -2 (e) N = -2, H = +1

53. (a) reduction (b) reduction (c) reduction (d) oxidation

55. (a) $Mn^{2+}(aq) + 4\,H_2O \rightarrow MnO_4^-(aq) + 8\,H^+(aq) + 5\,e^-$ (oxidation)

(b) $CrO_4^{2-}(aq) + 4\,H_2O + 3\,e^- \rightarrow Cr^{3+}(aq) + 8\,OH^-(aq)$ (reduction)

(c) $PbO_2(s) + 2\,H_2O + 2\,e^- \rightarrow Pb^{2+}(aq) + 4\,OH^-(aq)$ (reduction)

(d) $ClO_2^-(aq) + 2\,H^+(aq) + 2\,e^- \rightarrow ClO^-(aq) + H_2O$ (reduction)

57. (a) $O_2(g) + 4\,e^- \rightarrow 2\,O^{2-}(aq)$

(b) $MnO_4^-(aq) + 3\,e^- + 2\,H_2O \rightarrow MnO_2(s) + 4\,OH^-(aq)$

(c) $Cr_2O_7^{2-}(aq) + 6\,e^- + 14\,H^+(aq) \rightarrow 2\,Cr^{3+}(aq) + 7\,H_2O$

(d) $2\,Cl^-(aq) \rightarrow Cl_2(g) + 2\,e^-$

59. (a) $Ag(s) \rightarrow Ag^+(aq)$; $NO_3^-(aq) \rightarrow NO(g)$ Ag is oxidized (red. agent), NO_3^- is reduced (oxid. agent)

(b) $CO_2(g) \rightarrow C_2H_4(g)$; $H_2O(l) \rightarrow O_2(g)$ H_2O is oxidized (red. agent), CO_2 is reduced (oxid. agent)

61. (a)

$$\begin{aligned} 3[Ag(s) &\rightarrow Ag^+(aq) + e^-] \\ [NO_3^-(aq) + 3\,e^- + 2\,H_2O &\rightarrow NO(g) + 4\,OH^-(aq)] \\ \hline 3\,Ag(s) + NO_3^-(aq) + 2\,H_2O &\rightarrow 3\,Ag^+(aq) + NO(g) + 4\,OH^-(aq) \end{aligned}$$

(b)

$$\begin{aligned} [2\,CO_2(g) + 12\,e^- + 8\,H_2O &\rightarrow C_2H_4(g) + 12\,OH^-(aq)] \\ 3[4\,OH^-(aq) &\rightarrow O_2(g) + 4\,e^- + 2\,H_2O] \\ \hline 2\,CO_2(g) + 2\,H_2O &\rightarrow 3\,O_2(g) + C_2H_4(g) \end{aligned}$$

63. (a)

$$\begin{aligned} 8[Ni^{2+}(aq) &\rightarrow Ni^{3+}(aq) + e^-] \\ IO_4^-(aq) + 8\,H^+(aq) + 8\,e^- &\rightarrow I^-(aq) + 4\,H_2O \\ \hline 8\,Ni^{2+}(aq) + IO_4^-(aq) + 8\,H^+(aq) &\rightarrow 8\,Ni^{3+}(aq) + I^-(aq) + 4\,H_2O \end{aligned}$$

(b)

$$\begin{aligned} O_2(g) + 4\,e^- + 4\,H^+(aq) &\rightarrow 2\,H_2O \\ 2[2\,Br^-(aq) &\rightarrow Br_2(l) + 2\,e^-] \\ \hline O_2(g) + 4\,Br^-(aq) + 4\,H^+(aq) &\rightarrow 2\,Br_2(l) + 2\,H_2O \end{aligned}$$

(c)
$$3[Ca(s) \rightarrow Ca^{2+}(aq) + 2e^-]$$
$$Cr_2O_7^{2-}(aq) + 14\,H^+(aq) + 6e^- \rightarrow 2\,Cr^{3+}(aq) + 7\,H_2O$$
$$3\,Ca(s) + Cr_2O_7^{2-}(aq) + 14\,H^+(aq) \rightarrow 3\,Ca^{2+}(aq) + 2\,Cr^{3+}(aq) + 7\,H_2O$$

(d)
$$IO_3^-(aq) + 6e^- + 6\,H^+(aq) \rightarrow I^-(aq) + 3\,H_2O$$
$$3[Mn^{2+}(aq) + 2\,H_2O \rightarrow MnO_2(s) + 4\,H^+(aq) + 2e^-]$$
$$IO_3^-(aq) + 3\,Mn^{2+}(aq) + 3\,H_2O \rightarrow I^-(aq) + 3\,MnO_2(s) + 6\,H^+(aq)$$

65. (a)
$$SO_2(g) + 2\,OH^-(aq) \rightarrow SO_3(g) + 2e^-(aq) + H_2O$$
$$I_2(aq) + 2e^- \rightarrow 2\,I^-(aq)$$
$$SO_2(g) + I_2(aq) + 2\,OH^-(aq) \rightarrow SO_3(g) + 2\,I^-(aq) + H_2O$$

(b)
$$4[Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-]$$
$$NO_3^-(aq) + 8e^- + 6\,H_2O \rightarrow NH_3(g) + 9\,OH^-(aq)$$
$$4\,Zn(s) + NO_3^-(aq) + 6\,H_2O \rightarrow 4\,Zn^{2+}(aq) + NH_3(g) + 9\,OH^-(aq)$$

(c)
$$3[ClO^-(aq) + 2e^- + H_2O \rightarrow Cl^-(aq) + 2\,OH^-(aq)]$$
$$2[CrO_2^-(aq) + 4\,OH^-(aq) \rightarrow CrO_4^{2-}(aq) + 3e^- + 2\,H_2O]$$
$$3\,ClO^-(aq) + 2\,CrO_2^-(aq) + 2\,OH^-(aq) \rightarrow 3\,Cl^-(aq) + 2\,CrO_4^{2-}(aq) + H_2O$$

(d)
$$2[K(s) \rightarrow K^+(aq) + e^-]$$
$$2\,H_2O + 2e^- \rightarrow 2\,OH^-(aq) + H_2(g)$$
$$2\,K(s) + 2\,H_2O \rightarrow 2\,K^+(aq) + 2\,OH^-(aq) + H_2(g)$$

67. (a)
$$3[N_2H_4(l) \rightarrow N_2(g) + 4\,H^+(aq) + 4e^-]$$
$$2[BrO_3^-(aq) + 6\,H^+(aq) + 6e^- \rightarrow Br^-(aq) + 3\,H_2O]$$
$$3\,N_2H_4(l) + 2\,BrO_3^-(aq) \rightarrow 2\,Br^-(aq) + 3\,N_2(g) + 6\,H_2O$$

(b)
$$3[P_4(s) + 16\,H_2O + 8\,H^+(aq) \rightarrow 14\,H_2PO_4^-(aq) + 20e^- + 24\,H^+(aq)]$$
$$20[NO_3^-(aq) + 3e^- + 8\,H^+(aq) \rightarrow NO(g) + 2\,H_2O]$$
$$3\,P_4(s) + 20\,NO_3^-(aq) + 8\,H_2O + 8\,H^+(aq) \rightarrow 12\,H_2PO_4^-(aq) + 20\,NO(g)$$

(c)
$$5[SO_3^{2-}(aq) + H_2O \rightarrow SO_4^{2-}(aq) + 2e^- + 2\,H^+(aq)]$$
$$2[MnO_4^-(aq) + 5e^- + 8\,H^+(aq) \rightarrow Mn^{2+}(aq) + 4\,H_2O]$$
$$5\,SO_3^{2-}(aq) + 2\,MnO_4^-(aq) + 6\,H^+(aq) \rightarrow 5\,SO_4^{2-}(aq) + 2\,Mn^{2+}(aq) + 3\,H_2O$$

69. (a) $3[H_2C_2O_4(s) \rightarrow 2\,CO_2(g) + 2e^- + 2\,H^+(aq)]$

$2[MnO_4^-(aq) + 3e^- + 4\,H^+(aq) \rightarrow MnO_2(s) + 2\,H_2O]$

$3\,H_2C_2O_4(s) + 2\,MnO_4^-(aq) + 2\,H^+(aq) \rightarrow 6\,CO_2(g) + 2\,MnO_2(s) + 4\,H_2O$

(b) mol MnO_4^- = 0.0200 L × 0.300 mol/L = 6.00×10^{-3} ; mol $H_2C_2O_4 = 6.00 \times 10^{-3}$ mol MnO_4^-

$$\text{mol } H_2C_2O_4 = 6.00 \times 10^{-3} \text{ mol } MnO_4^- \times \frac{3 \text{ mol } H_2C_2O_4}{2 \text{ mol } MnO_4^-} = 9.00 \times 10^{-3}$$

$M = 9.00 \times 10^{-3}$ mol/0.0137 L = 0.657 mol/L

(c) mol MnO_2 = mol $MnO_4^- = 6.00 \times 10^{-3}$; mass $MnO_2 = 6.00 \times 10^{-3}$ mol × 86.94 g/mol = 0.522 g

71. (a) $H_2(g) + S(s) + 2\,OH^-(aq) \rightarrow S^{2-}(aq) + 2\,H_2O$

(b) $$\text{mol S} = \frac{3.00 \text{ g}}{32.07 \text{ g/mol}} = 0.0935 \text{ ; mol } OH^- = 2(\text{mol S}) = 0.187$$

$$\text{mol } Ba(OH)_2 = 0.187 \text{ mol } OH^- \times \frac{1 \text{ mol } Ba(OH)_2}{2 \text{ mol } OH^-} = 0.0935 \text{ ; } V = \frac{0.0935 \text{ mol}}{0.349 \text{ mol/L}} = 0.268 \text{ L} = 268 \text{ mL}$$

73. $MnO_4^-(aq) + 5\,Fe^{2+}(aq) + 8\,H^+(aq) \rightarrow Mn^{2+}(aq) + 5\,Fe^{3+}(aq) + 4\,H_2O$

mol MnO_4^- = 0.07552 L × 0.0205 mol/L = 0.00155

$$\text{mol Fe} = 0.00155 \text{ mol} MnO_4^- \times \frac{5 \text{ mol } Fe^{2+}}{1 \text{ mol } MnO_4^-} \times \frac{1 \text{ mol Fe}}{1 \text{ mol } Fe^{2+}} = 0.00774$$

mass Fe = 0.00774 mol × 55.85 g/mol = 0.432 g Fe; % Fe = 43.2 %

75. $$\text{mol AgCl} = \frac{4.95 \text{ g}}{143.4 \text{ g/mol}} = 0.0345 = \text{mol } Cl^- = \text{mol } OCl^- = \text{mol NaOCl}$$

mass NaOCl = 0.0345 mol × 74.44 g/mol = 2.57 g; mass bleach = 50.0 mL × 1.02 g/mL = 51.0 g

% NaOCl = (2.57/51.0) × 100% = 5.04 %

77. mol H^+ = (0.07500 L)(0.2500 mol HCl/L)(1 mol H^+/1 mol HCl) = 0.01875

mol OH^- = (0.01926 L)(0.150 mol NaOH/L)(1 mol OH^-/1 mol NaOH) = 0.00289

mol H+ reacting = 0.01875 – 0.00289 = 0.0156

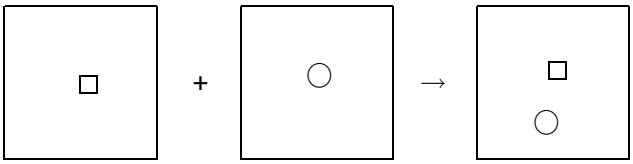
mol $CaCO_3$ = (0.01586 mol H^+)(1 mol $CaCO_3$/2 mol H^+) = 0.007930

mass $CaCO_3$ = (0.007930 mol)(100.09 g/mol) = 0.7937 g; % $CaCO_3$ = (0.7937/1.005)(100%) = 78.98 %

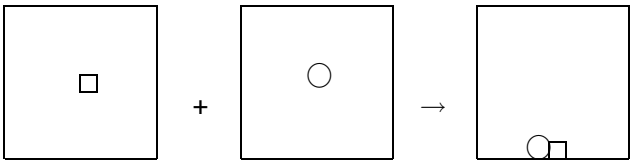
79. mol H^+ = mol HCl = (0.1000 L)(0.02500 mol HCl/L) = 0.002500
molH$^+$ unreacted = (0.05700 L)(0.03500 mol HCl/L) = 0.001995
mol H^+ reacted = $(2.500 \times 10^{-3}$ L) – $(1.995 \times 10^{-3}$) = 5.05×10^{-4}
mol NH_3 = $(5.05 \times 10^{-4}$ mol $H^+)$(1 mol NH_3/1 mol H^+) = 5.05×10^{-4}
mass NH_3 = $(5.05 \times 10^{-4}$ mol)(17.03 g/mol) = 8.60×10^{-3}g; mass air = 10.00 L × 1.19 g/L = 11.9 g
% NH_3 = $(8.60 \times 10^{-3}$ g/11.9 g)(100%) = 0.0723%; above OSHA limit

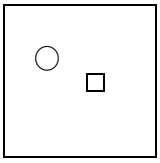
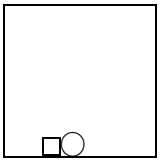
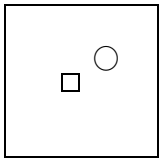
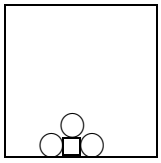
81. (a) $Cr_2O_7^{2-}$ (b) Sn^{2+} (c) $Cr_2O_7^{2-}$ (d) OH^-

83. (a) no reaction



(b)



85. (a)  (b)  (c)  (d) 

87. Ba^{2+}

89. All will occur.

91. $5\,CaC_2O_4(s) + 2\,MnO_4^-(aq) + 16\,H^+(aq) \rightarrow 10\,CO_2(g) + 2\,Mn^{2+}(aq) + 5\,Ca^{2+}(aq) + 8\,H_2O$
mol MnO_4^- = (0.0262 L)(0.0946 mol/L) = 2.48×10^{-3}
mol CaC_2O_4 = $(2.48 \times 10^{-3}$ mol)(5/2) = 6.20×10^{-3}
mass CaC_2O_4 = $(2.48 \times 10^{-3}$ mol)(128.1 g/mol) = 0.794 g
mass Ca = $(6.20 \times 10^{-3}$ mol)(40.08 g/mol) = 0.248 g; Yes

92. mol $Mg(OH)_2$ = (0.330 g)(0.410)(1 mol/58.32 g) = 0.00232

mol $NaHCO_3$ = (0.330 g)(0.362)(1 mol/84.01 g) = 0.00142

mol H^+ = 2(mol $Mg(OH)_2$) + mol $NaHCO_3$ = 2(0.00232) mol + 0.00142 mol = 0.00606

V = (0.00606 mol)(1 L/0.020 mol) = 0.30 L

93. Let x = mass Cu reacting; mass of Ag formed = $\frac{215.8}{63.55}x = 3.40x$

Total mass = 2.00 – x + 3.40x = 4.18 g

Solving: x = 0.908 g; mass Cu = 1.09 g; mass Ag = 3.09 g

94. $5\,Fe^{2+}(aq) + MnO_4^-(aq) + 8\,H^+(aq) \rightarrow 5\,Fe^{3+}(aq) + Mn^{2+}(aq) + 4\,H_2O$

(1) mol MnO_4^- = (0.0350 L)(0.0280 mol/L) = 9.80 $\times 10^{-4}$

mol Fe^{2+} = 5(mol MnO_4^-) = 5(9.80 $\times 10^{-4}$) = 4.90 $\times 10^{-3}$

$$M_{Fe^{2+}} = \frac{4.90 \times 10^{-3}\,\text{mol}}{5.000 \times 10^{-2}\,\text{L}} = 0.0980\ \text{mol/L}$$

(2) mol MnO_4^- = (0.0480 L)(0.0280 mol/L) = 1.34 $\times 10^{-3}$

mol Fe^{2+} = 5(mol MnO_4^-) = 5(1.34 $\times 10^{-3}$) = 6.72 $\times 10^{-3}$

mol Fe^{3+} = 6.72 $\times 10^{-3}$ mol - 4.90 $\times 10^{-3}$ mol = 1.82 $\times 10^{-3}$

$$M_{Fe^{3+}} = \frac{1.82 \times 10^{-3}\,\text{mol}}{5.000 \times 10^{-2}\,\text{L}} = 0.0364\ \text{mol/L}$$

95. mol OH^- = mol NaOH = (0.0336 L)(0.615 mol/L) = 0.0207

mol citric acid = (0.930 g)/(192.124 g/mol) = 0.00484

mol oxalic acid = (0.930 g)/(90.036 g/mol) = 0.0103

If oxalic acid : $H_2C_2O_4(aq) + 2\,OH^-(aq) \rightarrow H_2O + C_2O_4^{2-}(aq)$

1 mol oxalic acid uses up 2 moles OH^-: 0.0103 mol $H_2C_2O_4$ uses 0.0207 mol OH^-

Unknown is oxalic acid.

96. mol OH^- reacting = mol NaOH = (0.2382 L)(0.113 mol/L) = 0.0269

mol H^+ added = mol HCl = (0.625 L)(0.280 mol/L) = 0.175

mol H^+ reacting with $Fe(OH)_3$ = 0.175 mol – 0.0269 mol = 0.148

$$\text{mass } Fe(OH)_3 = 0.148\ \text{mol } H^+ \times \frac{1\ \text{mol } Fe(OH)_3}{3\ \text{mol } H^+} \times \frac{106.87\ \text{g } Fe(OH)_3}{1\ \text{mol}} = 5.27\ \text{g}$$